SECTION 5

CONCRETE PLACEMENT AND CONSOLIDATION

5-1 TRANSPORTATION

5-1.1 EQUIPMENT

Section 90-6.03 of the Standard Specifications in effect allows the Contractor to transport concrete by any means of conveyance, providing the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation, and providing the mixed concrete, after hauling, conforms to the requirements of Section 90-6.01 "General". This section establishes tests and criteria for mixed concrete suitable for placement.

Usually, concrete is delivered to the job site via truck transit-mixers. Due to their infrequent use, other methods of transportation such as truck agitators, open top vehicles, barges, etc., will not be discussed. These methods are used for special cases and should be individually investigated.

5-1.2 DELIVERY RATE

Since the rate of concrete placement affects the finishing operation, the Contractor's proposed or stipulated delivery rate warrants consideration.

Let's assume that the contractor plans to place 600 C.Y. at 45 C.Y./hr. This means that your pour will take a minimum of 13 hours plus. So if you start at 7:00 a.m., you'll finish placement and strike off around 8:30 p.m. The contractor tells

you that he has asked for 5 trucks, but can only get 4. However, he has been assured by the supplier that this will be more than ample as each truck carries 10 C.Y. of concrete. During previous pours, you have noticed that it takes roughly 5 minutes to discharge a 10 C.Y. truck, haul time to and from the plant is roughly 30 minutes each way, and it takes another 10 minutes to charge the mixer. Considering just the pour rate of 45 C.Y./hr., you need 4.5 trucks/hour or one every 13+, say 14 minutes. However, in order to keep up a steady rate of pour, one must consider the complete cycle a truck would make which is 75 minutes. Therefore, if we divide the 75-minute cycle by the 140 minute pour rate, we find 75/14 = 5.4 trucks or 6 trucks are needed. Inform the contractor, according to the figures he has supplied, that at least 6 trucks would be required to maintain 45 C.Y./hr. and that lights may be needed, a double shift worked, etc.

The secret of a successful pour is getting a good start and maintaining a constant delivery rate. Increased mechanization and decreased use of manual methods have allowed deck pours to proceed at a rate governed by the capacity of the finishing equipment and the rate of delivery and rarely by the physical limitations of the crew. Therefore, it is evident that generally, pour rates can be reduced to mathematical calculations with some allowances for mechanical malfunctions and very little allowance for the **human factor?

5-1.3 MIX CONSISTENCY AND UNIFORMITY

Section 90-6.01 of the Standard Specifications states that "All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement? Variations in consistency of the mix should be avoided. Changes in penetration, gradings, etc., have a cumulative effect on the ease of finishing, and are reflected in the finished surface.

5-1.4 INSPECTION AND TESTS

Methods and frequency of sampling and testing concrete are covered in the Concrete Technology Manual and the Construction Manual. Uniformity of mixed concrete is checked by differences in penetration (California Test 533) and variations in the proportion of coarse aggregate (California Test 529). The difference in penetration of two samples from the same batch or truck shall not exceed 1/2".

Concrete tickets, particularly those for the first loads should be checked for conformance with specification requirements. Section 90-6.03 of the Standard Specifications states that "Each load of ready-mixed concrete delivered at the jobsite, except loads used for pavement, shall be accompanied by a ticket showing volume of concrete, the concrete mix identification number, and the total amount of water added to the load. The ticket shall also show the time of day at which materials were batched and for transit-mixed concrete, the reading of the revolution counter at the time the truck mixer is

charged." Construction Memo 100-3.0 outlines the procedure to be used for checking load tickets. (See Appendix 5).

Section 90-6.03 of the Specifications also states that "No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless authorized by the Engineer." Furthermore, Section 90-6.06 of the Specifications gives limits as to the maximum amount of free water that can be incorporated into the concrete and also regulates the consistency of the concrete based on nominal penetration requirements.

Currently, the Contractor designs and proposes the use of a concrete mix based on the desired workability of the mix, the local resources available, and the requirements of the Standard Specifications (and Special Provisions). This mix may contain mineral and/or chemical admixtures to enhance the performance of the concrete so long as the use of these admixtures is approved by our Translab. The Engineer reviews the proposed concrete mix designs and approves the mixes that comply with the specifications.

After the concrete is delivered to the point of discharge, the Engineer usually allows the Contractor to regulate the amount of water that is added to the mix in order to maintain proper consistency and uniformity of the concrete. This places the responsibility on the Contractor, eliminating the need for constant inspection at the point of discharge. The Contractor knows not to exceed the maximum allowable water per the mix

design and/or the Standard Specifications for fear of rejection, and yet experience demands that the Contractor add enough water to get a workable mix.

It is very important to recognize that water should be added before the truck starts discharging. After discharge is started, the Contractor usually doesn't know the quantity of concrete with sufficient accuracy to add water with the assurance that the maximum water content will not be exceeded.

5-2 CONVEYANCE AND PLACEMENT

5-2.1 EQUIPMENT

In the past, Contractors have tried several different methods for placing concrete during deck pours. Buggies, conveyor belts, pumps, and buckets are a few of the more successful methods that have been used. Concrete buckets, pumps, and belts will be covered because these are the methods that have the greatest chance of being encountered out in the field.

5-2.1.1 CONCRETE BUCKETS

Obviously, when mentioning concrete buckets as a method of conveyance, we are referring to the crane-bucket method of placement. One cannot be considered without the other. Generally, we can assume an average pour rate of 45 C.Y./hr. when using one crane with two one-C.Y. buckets.

Some advantages of using the crane-bucket method are as follows: The crane can be utilized on other phases of work,

therefore, pours do not require special equipment and setup. The crane has a high degree of mobility which allows concrete placement under difficult conditions. A homogeneous mix is assured in most cases. Clean-up is minimal.

Some disadvantages of using the crane-bucket method are as follows: The crane's radii must encompass the pour front and often there are areas that are inaccessible. High pour rates require the use of additional cranes which leads to a safety problem with swinging booms. Overhead wires are a serious hazard. Impact due to concrete dropping from a high bucket can cause form failure.

When the crane-bucket method is used, care should be taken so that while the bucket is being filled with concrete it is positioned on a sheet of plywood in order to catch the spills and to keep the bottom of the bucket frame and boot out of the dirt.

5-2.1.2 CONCRETE PUMPS

Currently, concrete pumps are the most popular method for placing deck concrete. Truck-mounted pumps are more versatile and have higher pour rates than any other previously used method of conveyance. Present day pumps are expected to deliver up to 100 C.Y./HR without any major breakdowns or malfunctions. More favorable consideration is given to pumps due to this greatly increased reliability. In the past, pumps could be-expected to malfunction at least once during a pour. This increased

reliability and higher pour rate can be attributed to improvements in pump design and the increased use of admixtures.

Cranes with buckets and other previously used methods of conveyance are generally limited to a single or perhaps two locations for receiving ready-mix concrete, pumps are very mobile and can change locations very quickly. This is very important in keeping a fresh pour front for deck concrete placement. In areas where overhead airspace is congested with utility lines, etc., pumping is more advantageous because pumps normally require less headroom. Pumps also offer a less disruptive, ominous presence and are consequently less hazardous since the absence of swinging buckets or belts eliminates evasive maneuvering by the crew.

5-2.1.3 BELT CONVEYORS

During recent years, belt conveyors have been encountered on concrete pours where it is impractical or impossible to use pumps or buckets. Belts are utilized in areas that have impaired vertical clearances, traffic restrictions, and obstructions. Belts can produce pour rates of 65 C.Y./hr.

Some disadvantages of the belt are as follows: Often they require special supports or must be located along girder stems. Cleanup due to spillage is often a problem and care must be taken to place rugs or plastic sheathing at terminal points. Safety of the workers in the area of the terminal section requires special consideration. The chance of segregation is always present. Uneven pour fronts may result from removing support rail sections

as the pour progresses, thus causing inaccessible areas. Often unbalanced falsework loadings are encountered. Since the monitor must place concrete on both sides of the conveyor rail before it is moved back and the rail removed, the operator may fill one side completely before moving to the other. Rate of placement and placing sequence requires careful monitoring to assure proper vibration. Some belts must complete an entire 10' section before the finishing machine can move forward.

5-2.2 INSPECTION

Forms and surfaces that are to come into contact with the fresh concrete must be wet. Ponding of water should be prohibited. Uniform consistency of concrete and a uniform pour front parallel to the finishing machine should be maintained. The concrete must be adequately consolidated but not overvibrated. Reinforcing steel clearances should be continuously checked and displaced steel repositioned, blocked and tied, and broken dobies replaced, etc. The position of waterstops, deck drains, conduit, and prestressing hardware and appurtences should be checked and repositioned if displaced.

5.03 VIBRATION

Section 51-1.09 of the Standard Specifications states that "Concrete shall be placed and consolidated by methods that will not cause segregation of aggregates and will result in a dense homogeneous concrete which is free of voids and rock pockets."

Also, section 51-1.09 requires the contractor to consolidate all concrete by means of high frequency internal vibrators within 15 minutes after it is deposited in the forms.

Prior to vibration concrete presents a dry, irregular surface, while vibrated concrete presents a distinctively different appearance. Vibrated concrete takes on a moist #appearance as the fines move to the top and the large aggregates settle.

The technique of the operator should vary with the depths and complexity of the section. In deep sections where it is possible to get full penetration of the vibrator, it is imperative that the person operating the vibrator hit the concrete approximately every 2' and the head of the vibrator enter almost vertically. In thin deck sections the 2' separations must also be observed but it is not as important to enter the concrete vertically. Some may object to this statement, but considering the power of the vibrator and the depth of the section, it is not necessary to enter vertically for adequate consolidation.

The vibrator should not be dragged horizontally over the top of the concrete surface. Neither should the vibrator be allowed to run continuously while the operator is occupied with other things. Special care must be taken in vibrating areas where there is a high concentration of reinforcing steel.

Additional information on concrete placement and consolidation can be found in the Concrete Technology Manual.